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CONSULTANTS

Fauquier County, Virginia

FINAL REPORT

Task 2 - Alternatives for Improving Coverage in New Baltimore

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Background

In the autumn of last year, first responders in Fauquier County complained about the lack of radio coverage in particular neighborhoods in eastern sections of the County – especially just south of U. S. Route 29 near New Baltimore. The County asked CTA Communications to investigate the problem and to make recommendations for corrective action. A scope of work was developed for this engagement, and an amendment to our consulting services contract was agreed upon.

Task 1 in the scope was a test in which CTA's engineers measured outbound (base to mobile) received signal strength indication (RSSI). The testing was conducted March 14-16, 2006, and the test report was delivered to the County on April 25, 2006. We did indeed find areas with reduced signal strength on either side of U.S. Route 29 between New Baltimore and Buckland. The areas north of Rte. 29 are, however, much worse – the measured signal strength in some locations is so weak that communications to a mobile radio installed in a vehicle with a roof-mounted antenna would have trouble receiving dispatcher calls. The affected area north of Rte. 29 is a triangle formed by New Baltimore on the southwest corner, Buckland on the southeast and Broad Run to the north, with the Fauquier/Prince William County line on the east and the Pond Mountains to the west. While signal strength right along Route 29 seems adequate for portable use, the weak signal area begins about a mile north of the highway and extends about 3 miles to the north with a width of about 2 miles (east to west) starting at the crest of the Pond Mountains and going to the County line.

To the south of Route 29, the problem area appears to be less extensive and not as severe. Our test results indicated that while two-way mobile communications (i.e., to and from a vehicle) should be possible in almost all areas, portable radios would have spotty coverage from Rte. 29 extending south for about 1.5 miles from New Baltimore to the Prince William County line. Furthermore, communications with portable radios inside buildings would not be reliable in this 1.5 x 2.5 mile rectangle. This latter point is especially troublesome since Ritchie Elementary School, Auburn Middle School and the proposed new Fauquier High School all fall within this region of reduced signal strength.

Task 2 entails our assessment of the problem, identification of possible solutions and recommendations to the County. This report will present our observations and a list of possible alternative approaches for the County to consider. In the narrative we will explore some of the pros and cons of each approach. To assist Fauquier County in its deliberations, we have also prepared our opinion of probable cost for implementation of the various alternatives.

Observations

The result of our signal strength testing shown in FIGURE 1 illustrates the coverage problem area. The dots on the map indicate locations where test data from the Fauquier County 800 MHz public safety radio system were collected. (Note that our test vehicle was in motion when the signal was measured – this ensures that we will include the effects of multi-path fading in the data.) Blue dots indicate locations where the signal strength was -89 dBm or higher. We would expect good portable radio operation inside light buildings in these locations. (If the signal strength was greater than -85 dBm, we would expect good performance inside medium buildings; and if the signal strength was greater than -77 dBm, we would expect operations would be possible inside heavy buildings.) Green dots indicate portable coverage, but only from outdoor locations – inside even light buildings may be problematic. Yellow dots indicate mobile coverage – that is, only higher power radios installed in vehicles with roof-mounted antennas would be expected to maintain reliable communications. Red dots are locations where the signal strength was less than -108 dBm, and communications may be considered generally unreliable to standard subscriber radios.

We have marked off the area of interest with an isosceles triangle (red line) that traces the Fauquier/Prince William County line on the east, and the crest of the Baldwin Ridge and Pond Mountains on the west. The apex of the triangle is near Broad Run in the north. The southern boundary is just below Lunsford's Mountain and the Vint Hill Farms. This area includes Ritchie Elementary School, Auburn Middle School and the new Fauquier County High School site.

The coverage anomalies in the area of interest are almost certainly due to the local topography. Baldwin Ridge (south of U. S. Route 29) and the Pond Mountains (north of U. S. Route 29) are only a few hundred feet higher than the surrounding terrain, but they effectively block the 800 MHz signals from the View Tree Mountain and Marshall sites. Our problem area thus lies in a "radio shadow" formed by these hills. Diffraction effects and gaps in the ridge line (near Route 29, for instance) allow some signal to get through, making the coverage marginally acceptable in some locations, but causing drop-outs or holes in other spots. Areas south of Route 29 pick up some signal from Ensors Shop Road, though that site is approximately 15 miles southwest of New Baltimore. North of Route 29, the signal from Ensors Shop Road fades and the radio shadow cast by the Pond Mountains is significant, resulting in numerous areas where even mobile coverage is problematic.

Prior to the tests conducted in March 2006, CTA had been alerted to coverage problems reported in other areas of the County – specifically, in the southern regions near the Ensors Shop Road site. As a result, some signal level measurements were made in and around the other radio sites.

We noted severe imbalance at Ensors Shop Road (measured data indicated an imbalance of as much as 25 dB in some spots). From our inspection at ground level with a telephoto lens, the problem here was apparently due to poor installation practices. Since that earlier report, it is our understanding that the County has taken corrective action at Ensors Shop Road and had the 800 MHz antennas re-mounted in a proper manner. Anecdotal information indicates that radio performance in this area has improved significantly.

We recommend that the County inspect the other sites for similar conditions, and make reparations where indicated. The Remington site (SBA Tower), in particular, is a concern. From our inspections, it appeared that the installation hardware and methods used there were similar to those at Ensors Shop Road. Even though the antennas may still be secure there (at Remington), it may only be a matter of time before they break loose from the mountings and exhibit the same behavior as what we witnessed at Ensors Shop.

While we had harbored some hope that corrective action at existing simulcast sites would fix the observed coverage problems in the New Baltimore area, further analysis by CTA does not support this hypothesis. We ran our propagation model for Ensors Shop Road and examined the coverage provided by that site to the area of concern (the triangle shown in FIGURE 1 near New Baltimore). While mobile coverage from Ensors Shop should be possible everywhere south of Route 29, north of the highway our predicted maps showed mobile coverage becoming spotty. Portable coverage from Ensors Shop is restricted to the area south of Route 29, and is pretty spotty when you look at the predicted coverage inside buildings. These maps for Ensors Shop Road do not indicate a significant improvement in the New Baltimore area, even with all of the repairs that have been made. And the only two sites that are going to contribute to the coverage in the problem area are View Tree Mountain and Ensors Shop Road. Nothing in our earlier testing indicated faulty performance at View Tree.

When we conduct the coverage testing for the 800 MHz rebanding effort for Nextel, CTA will collect data in the problem area again. We can then compare this data to the March data (before the repairs were made at Ensors Shop). In our professional opinion, it is unlikely that the corrective work at Ensors Shop will have made a significant improvement to system performance. Therefore, we will examine several other alternatives in this report.

As you might imagine, these alternatives will have a full spectrum of complexity – both technical and operational, as well as a significant range in cost. There are many factors to be considered in each approach. Some are time-sensitive solutions, where a course of action could be taken today, but a delay lasting more than a few years may make the implementation impracticable.

In the following sections we will list the most obvious alternatives, giving a description of each, listing pros and cons, and finally providing our opinion of probable cost. A recommendation will be offered at the end of this report for your consideration.

Possible Alternatives

We believe it is necessary to evaluate as many potential solutions as possible in order to determine the most cost effective method to provide a resolution, without compromising operations for your public safety personnel. CTA has examined the following alternatives:

1. Repair only the observed antenna problems at the southern sites.
2. Optimize existing antenna patterns to maximize the signal in the New Baltimore area.
3. Install an outdoor bi-directional amplifier system to increase the signal in the area.
4. Install a non-simulcast site to allow coverage in the area for selected talk groups.
5. Borrow available coverage from the Prince William County system.
6. Utilize in-band vehicular repeaters to boost portable coverage.
7. Install an additional simulcast site.

Alternative 1 – Repair the Known Antenna Problems

This solution is necessary in order to restore proper coverage in the affected areas south of U. S. Route 29, and should proceed regardless of any other alternative selected. It is our opinion that no significant improvement in the New Baltimore area, much less the areas north of Route 29, will result from this corrective maintenance. The repair and reinstallation of antenna systems need to be pursued as an independent action, and not viewed as a fix for the spotty coverage in the New Baltimore problem area. Once the repairs are completed at all sites, it is recommended that the antenna balance be retested to verify that all problems have been corrected.

Alternative 2 – Antenna Optimization

This approach would require that the antennas at all sites contributing measurable RF signal to the New Baltimore problem area be oriented to deliver the maximum possible power level to the area east of Baldwin Ridge and the Pond Mountains. This could be done by moving transmit and receive antenna locations on the towers, and/or by replacing the omni-directional antennas with higher gain directional antennas.

From our propagation analysis, and due to the line-of-sight distances and topographic effects, we believe the increase in signal level would be quite modest. The small amount of increased

coverage obtained with this method would not make a significant improvement in the New Baltimore area.

Furthermore, any modification of antenna patterns could result in an unwanted reduction of coverage in other areas of the County. It would thus be a trade of slight improvement in New Baltimore for unknown problems elsewhere in the County. This is not a recommended approach.

Alternative 3 – Outdoor Bi-directional Amplifier

A bi-directional amplifier (BDA) is a specialized type of signal booster. It provides a solution that is commonly applied to the interior of heavy buildings, which naturally shield users from the radio system. For a BDA to be effective, a large amount of electrical isolation is required between the input and output antennas because there is no change in frequency, only a boost in the amplitude of the repeated signal.

If the area to be covered were extremely small – on the order of a square mile or so, an outdoor bi-directional amplifier could be a viable solution. Typically, this alternative is used to extend coverage into short mountain passes and other small areas that are close to, but hidden from a point where the signal level is high. A BDA requires relatively strong input signals in order to obtain the needed isolation between transmit and receive antennas operating on the same frequency. This is not a recommended solution for the problem area. However, we would like to emphasize the fact that BDAs are a common and very practical solution for specific locations such as inside large public use facilities like schools. A BDA system for one or more of the schools in the problem area is definitely a viable and cost-effective solution if we end up in a scenario where we have fixed the coverage in all the other outdoor and indoor locations. We recommend that the County proceed to a general solution for the coverage over the entire problem area, and then test indoor coverage in the three schools. If the measured reception inside the school buildings is still a problem, then and only then would we proceed with the design and deployment of an in-building BDA system.

Alternative 4 – Additional Non-Simulcast Site

Independent repeaters can be implemented in either of two designs. The first is a stand alone site with perhaps 2 or 3 channels connected into the main simulcast system so that talk groups would appear on both the main system and the stand alone site. This allows the users a seamless connection into the main system to communicate with other users on their talk groups.

Unfortunately, once a user is logged into the remote site, all calls for that user's talk group are routed to the site. With a small site comprising only 1 or 2 voice channels, this automatic routing

of calls may cause the site to become busy on all available channels quickly, which can cause delays when further calls are attempted. The two or three channels required would have to be new frequencies, which may pose a difficult licensing situation with the FCC.

The second type of independent repeater translates all of the main simulcast system channels to a separate set of frequencies. This prevents the congestion, but the scarce availability of 800 MHz frequencies in the congested northern Virginia area makes this design nearly impossible to use.

The lack of available frequencies in the northern Virginia area probably makes the use of either type of repeater difficult if not impossible at this time. The current re-banding effort might yield some additional frequencies for use in the area, but that is a long term solution with no assurances of success. This is not a favored solution but it may become necessary in the future. It should be noted that the cost of this solution would be less than a simulcast site (see alternative 6), but would still require the use of a tower and an equipment shelter and microwave equipment, which will entail similar costs to those for a simulcast site.

Alternative 5 – Borrow Coverage from Prince William County

FIGURE 2 shows the problem area with data we collected during the March tests – here we have plotted the signal strength of the control channel from the Prince William County 800 MHz radio system. We observed that there is good coverage available from the Prince William system in the New Baltimore area. Note that every measurement point where CTA gathered signal strength data for the Prince William County system is either colored blue or green. These colors indicate good portable on the street coverage (green), or good portable in light building coverage (blue). Medium and heavy building coverage was not plotted but would be smaller in area than the blue dots shown.

CTA has no knowledge about the availability of the Prince William system for users from Fauquier County, but this could be investigated. We do believe that the Prince William radio system is a Motorola ASTRO version 4.1 SmartZone simulcast system operating in the 800 MHz band. This would be nearly identical in operating characteristics to the system installed in Fauquier County, and they would be quite compatible.

A possible solution would involve an agreement between Prince William and Fauquier Counties where Fauquier first responders have permission to “roam” onto the Prince William system when the Fauquier signal is lost. The Fauquier users would use the Fauquier system as their first choice, but when they lose the channel entirely, they could switch to the Prince William talk group instead. A patch tying the talk group on the Fauquier system to the talk group on the Prince William system would have to be established at the Fauquier dispatch console. This can

be pre-determined if the firefighters or deputies know in advance that they are being dispatched to an area or building that is known to have poor coverage.

We suggest that this function be quite limited in use – restricted to only those users that have “first response” responsibility for the problem area in Fauquier County. Furthermore, the talk groups should be limited to the group that has this responsibility – perhaps a Sheriff’s group and a Fire/Rescue group. These restrictions are necessary to limit the “wide area” calls that could cause channel congestion on both Fauquier and Prince William systems.

Connectivity between the Warrenton/Fauquier Joint Communications Center (WFJCC) and the Prince William radio system could be made via an RF link with Fauquier control stations programmed on Prince William frequencies. A patch between the designated Fauquier and Prince William talk groups would be made at a console position at the WFJCC. The patch could be made permanent with the addition of network equipment at the View Tree Mountain “master site”. A more robust link utilizing either licensed microwave or leased T1 lines could be pursued if the two counties wanted to make this a permanent function.

There are several drawbacks to this alternative. The most obvious, and least technical, is the joint use agreement that Fauquier County would need to negotiate with Prince William County. It is an agreement that Fauquier users need, but would not particularly benefit Prince William, other than a general improvement in interoperability. The additional traffic on the Prince William system could lead to channel congestion resulting in “busies” and call delays. It is quite possible that even if the signal is improved in the Fauquier problem area, the in-building coverage at Ritchie Elementary School, Auburn Middle School and the new County High School might still be unacceptable. From an operational standpoint, it might be confusing for some agencies to have “special” procedures for certain personnel, or for certain assignments. It is always better for procedures to be consistent and uniform. Finally, it should be understood that this arrangement would place Fauquier County in a position where they are dependent on Prince William County maintaining their system. If Prince William decided to upgrade their system to a new technology (e.g., P25), Fauquier would be forced to upgrade their system as well (or to seek an alternate, independent solution).

Even though CTA does not recommend this alternative as a permanent fix, if the Prince William system can be utilized on a temporary basis, we feel that it is a viable solution to the problem for the short term. Assuming that Prince William County is in agreement, this temporary fix could be implemented quickly and economically. It would provide reasonable coverage in all the areas of concern, though it is not likely to provide the level of in-building coverage desired at all three of the County schools in the affected area. A temporary agreement should be much easier to

negotiate, and many of the potential problems foreseen in a permanent arrangement would not be a concern – e.g., migration to new technologies.

Alternative 6 – Vehicular Repeaters

It has been suggested that the use of in-band vehicular repeaters could be used to enable portable coverage in the problem area. This vehicular repeater is a relatively new product that consists of a “back-to-back” assembly of mobile radios. Mobile radio # 1 communicates on a talk group with the trunked radio system. The calls would be repeated on mobile radio # 2 which would place calls on a separate, conventional channel in a direct radio-to-radio or “talk around” mode (not on the radio system). Both calls would be carried in the 800 MHz band.

There are several issues that need to be studied if this alternative is seriously considered as a solution. The first is that the number of talk groups involved in an incident will be limited by the number of “talk-around” conventional channels that the County has licensed. There will only be one group for each vehicular repeater at a scene. If multiple groups are needed, additional vehicles will have to be deployed, limited by the number of channels that the County has access to. Also, it should be realized that the operational use of these repeaters will be different than the trunked operation on the main system. We encourage firefighters to use this technology for in-building coverage in situations where the signal level is marginal. However, other public safety and general government users may not be familiar with operations where they switch from trunked to conventional mode of communications on an *ad hoc* basis.

At a cost of approximately \$10,000 per repeater, it is doubtful that the County would elect to outfit all vehicles with this equipment. If the equipment is installed in only selected vehicles, it would be important to track those vehicles and assign them to the problem area, making sure that one is always on scene at an incident. This will require careful planning and coordination by the County agencies and by the dispatchers at WFJCC.

A vehicular repeater could be permanently installed at one or more of the schools to provide conventional portable use. However, if the conventional frequency used in the building can be monitored outside the building, it will limit the use of that frequency elsewhere in the problem area. For this reason, we would recommend that bi-directional amplifier (BDA) systems be considered for in-building coverage at the schools. Careful testing and design of these systems can minimize the cost to the County.

We note that while this method of communications would work well in certain locations, there are areas that were measured with inadequate signal strength to even support mobile communications. Without a mobile-to-base link, the vehicular repeater will not function. For

this reason, CTA believes that this approach does not offer a good permanent solution. However, like the Prince William solution offered in Alternative 5 above, the use of vehicular repeaters could be a viable short-term fix.

Alternative 7 – New Simulcast Site

This alternative involves the development effort associated with a new site similar to the one built at Ensors Shop Road. Issues include land acquisition, zoning, shelter, tower, generator, fuel system, fencing, RF equipment and additions to the Master Site at View Tree Mountain. It is also likely that implementation would take a year or more due to licensing and land acquisition issues. Any public opposition to a new tower site could delay the project even more.

CTA has performed computerized evaluations of the probable coverage for four potential site locations. The analysis method we used evaluates 25 locations or points within each square mile and produces estimates of coverage based on a 90% contour reliability – this equates to a 95% area reliability. The maps that were generated also present the measured results from the recently completed received signal strength test to allow before and after comparison. Each site has both good and bad points which are discussed in the following sections. In our opinion, this is the best long-term or permanent solution. It provides a situation where the County has complete control, and where the coverage is truly fixed. After implementation of the solution, operations in the problem area would be identical to everywhere else in the County.

It is important to put this alternative in the context of events and plans that are beyond the control of the County. The first point to consider is the announced product plans at Motorola. Fauquier County's 800 MHz radio system is a SmartZone version 4.1 mixed mode (analog and ASTRO digital). The hardware design, software and control channel protocol are proprietary to Motorola. In early 2004 Motorola announced that it would no longer accept orders for new ASTRO version 4.1 systems, and in fact shipped its last complete system in December 2004. This should not be viewed as alarming news as Motorola has a continuing commitment to support the hundreds of public safety systems already installed around the country, including the one in Fauquier County. However, Motorola does have a product phase out program that includes a schedule for infrastructure such as repeaters, comparators and other essential elements of your system. The County can place an order for equipment to furnish an additional simulcast site, but only until 2009. After that time, you will no longer have this option available. (Channel capacity can be added after 2009, and subscriber equipment like mobiles and portables will be available until at least 2017.)

The second factor to consider is the rebanding effort already underway in the County. The FCC has frozen applications for new frequencies in the 800 MHz band. This freeze also applies to

modifications to existing licenses – like adding a new site to a license. Until the implementation of the rebanding plan has been completed in Region 20 (which includes the Washington, DC area and Fauquier County), moving forward with the license modification may be slow.

In the following we will discuss each of the four possible sites that we have identified as a possible sixth site in Fauquier's simulcast network. It should be kept in mind that these are not necessarily the only locations, but are used here to show feasibility and as an aide in developing cost estimates for this alternative.

Vint Hill Site

Use of the 400-foot tower at Vint Hill for the sixth simulcast site in the Fauquier County public safety radio system is the preferred alternative. The tower appears to be lightly loaded and should be able to accommodate the antennas needed for an expansion of the radio system. (CTA has no information about the owner's future plans for this site.) If the County can gain access, the development costs for a sixth site would be minimized if this location can be used.

FIGURES 3 through 7 show the radio coverage offered by locating 800 MHz antennas at the top of this tower (red triangle). FIGURE 3 illustrates mobile coverage; FIGURE 4 shows outdoor portable coverage (with portable at hip level); FIGURE 5 shows portable inside light buildings (e.g., one or two story houses); FIGURE 6 shows portable inside medium buildings (three to six story buildings, commercial construction); and FIGURE 7 shows portable inside heavy buildings (industrial construction, box stores, buildings having few windows, tall buildings greater than 6 stories).

FIGURE 8 shows the signal data collected in the field overlaying an alternate propagation estimate (run at an earlier date than those shown in FIGURES 3 through 7). However, the result is quite similar. Our analysis indicates that the coverage at all three school locations will be in the heavy building category. This would eliminate the need to install bi-directional amplifier systems inside these structures, potentially saving the County hundreds of thousands of dollars. Likewise, the coverage in the Vint Hill area would likely penetrate the warehouses and most other industrial or commercial buildings in the area. The new housing developments in New Baltimore and the vicinity of the old Vint Hill military compound also appear to have excellent coverage. In the northern sector of the problem area, where the existing coverage is the worst, it appears that there would be a considerable improvement. Radio operations inside light buildings should be in excess of 95% in the problem area, as shown by FIGURE 5.

In our professional opinion, a microwave path is viable from this site to the View Tree Mountain site. A detailed path analysis has not been performed, but will be required before committing to

this option. Since this is a new path, the County could opt for a broadband, high-capacity microwave link to Vint Hill. Use of an OC-3 SONET radio would open Vint Hill to the option of point-to-point high-speed data for the County Parks & Recreation Department, County Schools, and any other applications that the IT department might consider for future use. Only a single DS-1 (one T1) is needed for the radio site. However, the cost to install a high-capacity link is only a slight increase to the cost of the equipment. CTA can advise the County on how to accomplish this goal at minimum cost.

If for some reason, the Vint Hill tower is not available for the sixth site, we offer three other possible locations in the following pages. These sites are labeled FX-1, FX-2 and FX-3.

FX-1 Site

If property is available, the FX-1 site would require a full development effort. It is very close to a public road. The coverage estimates were made using an assumed 90 foot tower height that would minimize the exposure of the antennas above the trees.

FIGURE 9 shows the predicted signal strength. The coverage at two of the three school locations appears to be in the heavy building category. The new housing developments in the vicinity of the old Vint Hill military compound also appear to have good coverage. In the vicinity of the new high school as well as Auburn Middle School the coverage is approaching the limits of heavy building coverage, indicating that the final solution may require a bi-directional amplifier system at the school. It is probable that a bi-directional amplifier will be needed at Ritchie Elementary.

In the northern sector of the problem area, where the existing coverage is the worst, it appears that the coverage from this site will be slightly better than the coverage from Vint Hill.

Outside of the problem area to the west of Pond Mountain is an area of mobile only coverage measurement points as indicated by the yellow dots. The prediction indicates this area would benefit slightly from the FX-1 site coverage.

A clear microwave path is indicated to the View Tree Mountain site. A detailed path analysis would be required prior to committing to this option. Point-to-point, high-capacity data links may not be an option from this site due to the limited height of the tower.

FX-2 Site

FX-2 is a relatively low lying site that would require a full development effort if the land is available. It is close to a public road, but a moderate effort would be required to gain access and provide power. Coverage estimates were done with a 90 foot tower to minimize the intrusion into the neighborhood.

FIGURE 10 shows the predicted signal strength. The coverage at Ritchie Elementary school appears to be in the heavy building category. The middle school and the high school may require bi-directional amplifiers to provide indoor coverage. The new housing developments in the vicinity of the old Vint Hill military compound also appear to have good coverage.

In the northern sector of the problem area where the existing coverage is the worst, it appears that the coverage from this site will be much better than the coverage from any other potential or existing site.

A solution would need to be found for providing connectivity into the existing system as no direct microwave path is possible. It may be possible to utilize Vint Hill or a similar site as a repeater site as shown in FIGURE 12. It is also possible to extend connectivity to this site by using a leased T-1 line as an alternative to microwave. Point-to-point, high-capacity data links may not be an option from this site due to absence of a clear path to View Tree Mountain.

FX-3 Site

FX-3 is a relatively low lying site that would require a full development effort if the land is available. It is close to a public road, but a moderate effort would be required to gain access and provide power. Coverage estimates were done with a 90 foot tower to minimize the intrusion into the neighborhood.

FIGURE 11 shows the predicted signal strength from this site. The coverage at the Ritchie Elementary School location appears to be in the heavy building category. The middle and high schools may require bi-directional amplifiers to provide indoor coverage. The new housing developments in the vicinity of the old Vint Hill military compound also appear to have good coverage.

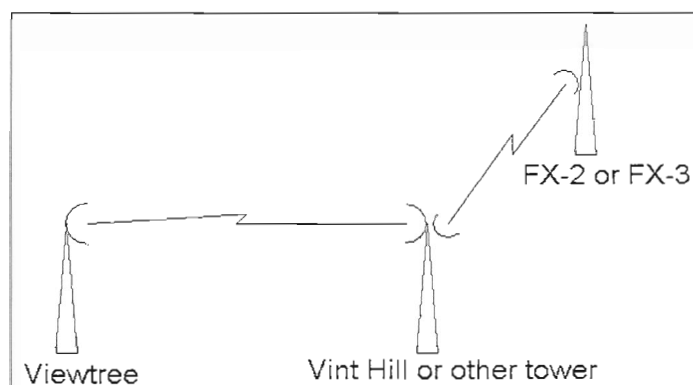
In the northern sector of the problem area where the existing coverage is the worst, it appears that the coverage provided by this site would be greatly improved over the existing coverage.

A solution would need to be found for providing connectivity into the existing system as no direct microwave path is possible. It may be possible to utilize Vint Hill or a similar site as a repeater site as shown in FIGURE 12. It is also possible to extend connectivity to this site by using a leased T-1 line as an alternative to microwave. Point-to-point, high-capacity data links may not be an option from this site due to absence of a clear path to View Tree Mountain.

Interconnect Configurations for the FX-2 and FX-3 Potential Sites

In the event that the County decides to utilize either the FX-2 or the FX-3 site, or any similar site that is hidden from existing towers, it will be necessary to add a microwave repeater or utilize a T-1 land line circuit. The path lengths are relatively short and do not require space diversity operation. Monitored hot standby is the preferred microwave system configuration. RF equipment should be compatible with the existing County equipment for good maintenance support, but could use a lower capacity radio in the 1DS1 or 2DS1 range to save cost. Multiplex would consist of a single T-1 circuit but could be expanded later as needs change. If Vint Hill is not available, any point with a common view of the 2 ends of the link could be utilized.

FIGURE 12 Potential Microwave Repeater



Engineer's Opinion of Probable Cost

This section of our report contains budgetary cost estimates for the various alternatives discussed above, with particular detail given to the four possible site locations in Alternative 7 (new simulcast site). Also included is information on the basis of the cost estimate, and various possible upgrade scenarios.

Estimates were developed for the major categories of equipment as they apply to the preliminary design as described earlier in this report. The equipment, installation and vendor service cost information were obtained from historical CTA Communications cost files and vendor pricing of

comparable projects. These costs were compared and weighted in order to derive an average "list price" type for a turnkey procurement. Turnkey pricing is appropriate for your project at the budget planning stage.

Costs for Alternatives 1 and 2 (repair antenna systems and optimize antenna directivity, respectively) would be quite minimal – probably less than \$50,000, and most of this would pay for a thorough coverage test in the problem area. However, CTA does not recommend that either of these approaches be seriously considered as a solution.

Alternative 3 (outdoor bi-directional amplifier) will range in cost from approximately \$25,000 to \$100,000, depending on the specifics of the installation. This is not a recommended approach, so we did not pursue the detailed cost issue in depth. The cost for bi-directional amplifier systems in the three schools is, however, dealt with in some detail in Alternative 5 below.

Alternative 4 (non-simulcast site) would have a cost similar to that for a new simulcast site in several important areas: physical facilities (tower, building, generator, etc.), microwave equipment and vendor services. The savings would occur primarily in the fixed network equipment at the Master/Prime Site (View Tree Mountain) as well as at the new radio site. We estimate the cost for this option could range from about \$800,000 to as much as \$1,300,000, depending on the specific site selected. Substitution of a leased T1 line in place of the microwave link could reduce the capital cost for this option, although it would add a recurring cost for the service. Also, leased lines have a lower reliability than microwave links. We have not developed detailed costs for this option, as it is not a recommended approach.

Alternative 5 (borrowing coverage from Prince William County) is a viable short-term solution for Fauquier County, considering the cost savings and the existing availability of sufficient radio signal. Although Prince William does provide adequate coverage from their system, there is still likely to be some cost for implementing this solution. It is unlikely that the small amount of radio traffic introduced by Fauquier would jeopardize Prince William's operations, but it must be considered in a worst-case scenario.

In order to implement this alternative, the two systems would need to have an RF link tying the talk-groups together. This can be accomplished with a Base Interface Module (BIM) and a desktop/control station at View Tree Mountain. A patch should then be established at the Warrenton/Fauquier Joint Communications Center. The cost for configuring the two systems this way could be minimal if there is adequate channel capacity in Prince William and if the County has an available BIM slot. The cost for a control station at View Tree Mountain, programming costs for the BIM and console patch, could run as low as \$10,000.

Although the Prince William system appears to provide adequate coverage for the problem area near New Baltimore, it is not clear that there will sufficient signal strength inside the school buildings to support portable communications. If sufficient signal is not present in the school buildings, the County could elect to add a bi-directional amplifier (BDA) system at each location. We estimate the cost for the BDA at Ritchie Elementary School to be \$60,000 to \$75,000. The cost at Auburn Middle School could range between \$80,000 and \$100,000, while the cost at the new high school could run from \$100,000 to \$150,000. Part of the variability here would depend on the areas in the building where radio coverage is needed or desirable.

Alternative 6 (vehicular repeaters), also considered a viable interim solution, would entail the cost for the 800 MHz vehicular repeaters, plus programming and installation. If the County budgeted \$10,000 per vehicle, this should be adequate. Note, however, that use of this alternative as a permanent solution would probably impose the installation of BDA systems at each of the schools in the area, at a cost ranging from \$240,000 to \$325,000.

The cost for Alternative 7 (new simulcast site) was subdivided into three possible scenarios – one for Vint Hill tower (Option 1), one for the FX-1 site (Option 2) and one for either FX-2 or FX-3 (Option 3), which are similar in cost. Each of these scenarios would involve upgrades and additional equipment at View Tree Mountain as well as at the new radio site, and in Option 3 at an ancillary microwave repeater site.

The list costs shown in the following tables are recommended for planning and budgetary purposes only. While CTA Communications cannot guarantee bid price levels, our experience has shown that successful competitive bidding typically results in savings on the list price costs. Competitive bidding would be possible for the microwave equipment and the physical facilities. The simulcast radio equipment would, of course, have to be procured from Motorola. If the County issues a purchase order prior to the end of 2007, we believe that Motorola will be obligated to honor the discounts contained in the original contract for the 800 MHz system. In any case, CTA believes that the total cost of the project will likely fall in the range between the “High Estimate” and “Low Estimate”.

Option 1 – Vint Hill Site

The table for Option 1 shows our opinion of probable cost for the implementation of an 8-channel simulcast radio site at the existing Vint Hill tower site. Cost detail is shown in six categories: Radio Infrastructure, Microwave, Physical Facilities, Vendor Services, Fixed Spares and Contingency.

Radio Infrastructure includes the following fixed network equipment and associated software at the Master/Prime Site at View Tree Mountain:

- Re-programming of the Master Site Controller and SmartZone Controller
- Necessary adjustments to the simulcast timing for the sixth site
- Accommodations for a sixth site in the Comparators
- Accommodations for a sixth site in the MOSCAD Monitoring and Alarm system

At Vint Hill, the Radio Infrastructure covers the following:

- Remote Site Controller
- 8 Simulcast Repeaters
- Transmit Combiners, a Multicoupler and a Tower Top Amplifier
- 800 MHz Antenna systems for both transmit (2 antennas) and receive (1 antenna)
- Remote Site MOSCAD Alarm Terminal
- Simulcast Control Equipment including GPS Receiver and back-up timing source (Rubidium Oscillator)

The Microwave cost element includes a complete set of equipment at both View Tree Mountain and at Vint Hill:

- Monitored Hot Standby Configuration for 6 or 11 GHz Radios
- Antenna System including dishes, dehydrator/pressurization unit, waveguide, etc.
- DC Power System (either -48 VDC or -24 VDC)
- TeNSr Channel Banks and Multiplexers

Physical Facilities at Vint Hill would include:

- Tower Analysis (for structural integrity with new antenna loading)
- Site preparation & refurbishment
- New Building with Grounding system, HVAC, ventilation
- Emergency gas generator
- UPS
- Fire Suppression system

We did not include tower upgrades or replacement at Vint Hill. Physical Facilities at View Tree Mountain would be minimal, unless the new equipment posed space problems.

Vendor Services include systems engineering, project management, site management, system optimization, testing and technical training.

Fixed Spares are included for the infrastructure modules and parts inventory to be held by the County (or by the County's service shop).

Contingency is a 10% margin applied to the sum of the cost figures for Radio Infrastructure, Microwave and Physical Facilities. It is prudent to include this contingency in the budgetary planning for the project.

Option 2 – FX-1 Site

The table for Option 2 shows our opinion of probable cost for the implementation of an 8-channel simulcast radio site at the hypothetical FX-1 tower site. This site is similar to the Vint Hill case shown in Option 1 in that a direct path to View Tree Mountain is feasible for the microwave link to the Master/Prime Site there. Cost detail is shown in six categories: Radio Infrastructure, Microwave, Physical Facilities, Vendor Services, Fixed Spares and Contingency.

Radio Infrastructure includes the following fixed network equipment and associated software at the Master/Prime Site at View Tree Mountain:

- Re-programming of the Master Site Controller and SmartZone Controller
- Necessary adjustments to the simulcast timing for the sixth site
- Accommodations for a sixth site in the Comparators
- Accommodations for a sixth site in the MOSCAD Monitoring and Alarm system

At the FX-1 site, the Radio Infrastructure covers the following:

- Remote Site Controller
- 8 Simulcast Repeaters
- Transmit Combiners, a Multicoupler and a Tower Top Amplifier
- 800 MHz Antenna systems for both transmit (2 antennas) and receive (1 antenna)
- Remote Site MOSCAD Alarm Terminal
- Simulcast Control Equipment including GPS Receiver and back-up timing source (Rubidium Oscillator)

The Microwave cost element includes a complete set of equipment at both View Tree Mountain and at FX-1:

- Monitored Hot Standby Configuration for 6 or 11 GHz Radios
- Antenna System including dishes, dehydrator/pressurization unit, waveguide, etc.
- DC Power System (either -48 VDC or -24 VDC)
- TeNSr Channel Banks and Multiplexers

Physical Facilities at FX-1 would include:

- Site preparation (clearing, grubbing, grading, etc.)
- Access road & parking area
- Fencing around compound
- New 90-foot Tower, including foundation
- New Building with Grounding system, HVAC, ventilation
- Emergency gas generator
- UPS
- Fire Suppression system

Physical Facilities at View Tree Mountain would be minimal, unless the new equipment posed space problems.

Vendor Services include systems engineering, project management, site management, system optimization, testing and technical training.

Fixed Spares are included for the infrastructure modules and parts inventory to be held by the County (or by the County's service shop).

Contingency is a 10% margin applied to the sum of the cost figures for Radio Infrastructure, Microwave and Physical Facilities. It is prudent to include this contingency in the budgetary planning for the project.

Option 3 – FX-2 or FX-3 Site

The table for Option 3 shows our opinion of probable cost for the implementation of an 8-channel simulcast radio site at either the hypothetical FX-2 or FX-3 tower site. Either of these sites are similar to the FX-1 case shown in Option 2 in that a new 90-foot tower would be constructed, and full development of the site would be required. However, in this option we

assumed that a direct path to View Tree Mountain is not feasible for the microwave link. An intermediate site must therefore be included in the plans – it will act as a relay or repeater site for the microwave signals only. Cost detail is shown in six categories: Radio Infrastructure, Microwave, Physical Facilities, Vendor Services, Fixed Spares and Contingency.

Radio Infrastructure includes the following fixed network equipment and associated software at the Master/Prime Site at View Tree Mountain:

- Re-programming of the Master Site Controller and SmartZone Controller
- Necessary adjustments to the simulcast timing for the sixth site
- Accommodations for a sixth site in the Comparators
- Accommodations for a sixth site in the MOSCAD Monitoring and Alarm system

At the FX-2 or FX-3 site, the Radio Infrastructure covers the following:

- Remote Site Controller
- 8 Simulcast Repeaters
- Transmit Combiners, a Multicoupler and a Tower Top Amplifier
- 800 MHz Antenna systems for both transmit (2 antennas) and receive (1 antenna)
- Remote Site MOSCAD Alarm Terminal
- Simulcast Control Equipment including GPS Receiver and back-up timing source (Rubidium Oscillator)

The Microwave cost element includes a complete set of equipment at View Tree Mountain and at FX-2 or FX-3, as well as at a third site (perhaps Vint Hill or some other point with a clear view of both View Tree and FX-2 or FX-3):

- Monitored Hot Standby Configuration for 6 or 11 GHz Radios (repeaters at the intermediate microwave site)
- Antenna System including dishes, dehydrator/pressurization unit, waveguide, etc. (two sets of dishes and antenna systems at the intermediate microwave site)
- DC Power System (either -48 VDC or -24 VDC)
- TeNSr Channel Banks and Multiplexers (only at View Tree and FX-2 or FX-3)

Physical Facilities at FX-2 would include:

- Site preparation (clearing, grubbing, grading, etc.)
- Access road & parking area

- Fencing around compound
- New 90-foot Tower, including foundation
- New Building with Grounding system, HVAC, ventilation
- Emergency gas generator
- UPS
- Fire Suppression system

Physical Facilities at View Tree Mountain would be minimal, unless the new equipment posed space problems. The physical facilities costs at the intermediate microwave site were included as \$33,300 based on minimal work required at Vint Hill if that site were simply used for this limited purpose.

Vendor Services include systems engineering, project management, site management, system optimization, testing and training.

Fixed Spares are included for the infrastructure modules and parts inventory to be held by the County (or by the County's service shop).

Contingency is a 10% margin applied to the sum of the cost figures for Radio Infrastructure, Microwave and Physical Facilities. It is prudent to include this contingency in the budgetary planning for the project.

Items Not Contained in the Estimates

The following cost items are not included in the estimate for any of the three options above:

- Land or property acquisition, including leasing
- Permitting or zoning the sites or properties
- Environmental impact studies
- Mutual Aid stations
- Preparation of engineering exhibits for FCC License modifications
- Engineering or consulting services for preparation of specification, assistance with procurement and negotiations, construction administration and independent oversight of acceptance testing

OPTION 1 UTILIZE EXISTING VINT HILL SITE
OPINION OF PROBABLE COST
FAUQUIER COUNTY, VIRGINIA

		LIST COST		HIGH ESTIMATE		LOW ESTIMATE	
RADIO INFRASTRUCTURE	100%		\$ 513,300	85%	\$436,300	75%	\$ 385,000
MICROWAVE	100%		\$ 438,200	90%	\$ 394,300	90%	\$ 394,300
PHYSICAL FACILITIES	100%		\$ 198,100	90%	\$ 178,300	90%	\$ 178,300
VENDOR SERVICES	100%		\$ 206,900	85%	\$ 175,900	75%	\$ 155,200
SPARES - FIXED	100%		\$ 11,500	100%	\$ 11,500	100%	\$ 11,500
CONTINGENCY	100%		\$ 115,000	90%	\$ 103,500	80%	\$ 92,000
TOTAL			\$ 1,483,000		\$ 1,299,800		\$ 1,216,300

OPTION 2 NEW SITE WITH DIRECT MICROWAVE LINK TO VIEW TREE
OPINION OF PROBABLE COST
FAUQUIER COUNTY, VIRGINIA

	LIST COST		HIGH ESTIMATE		LOW ESTIMATE	
RADIO INFRASTRUCTURE	100%	\$ 513,400	85%	\$ 436,300	75%	\$ 385,000
MICROWAVE	100%	\$ 438,200	90%	\$ 394,300	90%	\$ 394,300
PHYSICAL FACILITIES	100%	\$ 417,300	90%	\$ 375,600	90%	\$ 375,600
VENDOR SERVICES	100%	\$ 246,400	85%	\$ 209,400	75%	\$ 184,800
SPARES - FIXED	100%	\$ 13,700	100%	\$ 13,700	100%	\$ 13,700
CONTINGENCY	100%	\$ 136,900	90%	\$ 123,200	80%	\$ 109,500
TOTAL		\$ 1,765,900		\$ 1,552,500		\$ 1,462,900

OPTION 3 NEW RF SITE PLUS MICROWAVE MIDPOINT REPEATER
OPINION OF PROBABLE COST
FAUQUIER COUNTY, VIRGINIA

	LIST COST		HIGH ESTIMATE		LOW ESTIMATE	
RADIO INFRASTRUCTURE	100%	\$ 513,400	85%	\$ 436,300	75%	\$ 385,000
MICROWAVE	100%	\$ 656,000	90%	\$ 590,400	90%	\$ 590,400
PHYSICAL FACILITIES	100%	\$ 450,600	90%	\$ 405,500	90%	\$ 405,500
VENDOR SERVICES	100%	\$ 291,600	85%	\$ 247,900	75%	\$ 218,700
SPARES - FIXED	100%	\$ 16,200	100%	\$ 16,200	100%	\$ 16,200
CONTINGENCY	100%	\$ 162,000	90%	\$ 145,800	80%	\$ 129,600
TOTAL		\$ 2,089,800		\$ 1,842,100		\$ 1,745,400

Conclusions and Recommendation

We have carefully considered a variety of possible alternatives for solving the coverage problems in the New Baltimore area. While a number of these do not seem either feasible or likely to succeed, Alternatives 5 and 6 provide viable short-term fixes, but do not offer robust permanent solutions. Alternative 7 (the addition of a sixth simulcast site to the County's public safety radio system) is the only option that truly solves the problem in the New Baltimore area. And of the options considered for the sixth site, by far the best and most economical candidate is the existing 400-ft. tower site at Vint Hill.

By utilizing the Vint Hill tower, the County would be capitalizing on an existing facility and not asking citizens to accept a new tower that would impinge on the natural view-shed. The cost for a new tower would be considerable, so if the existing 400-ft. guyed tower meets the current standards for wind loading, this would be an economical choice. (A 400-ft. tower could cost several hundred thousand dollars if built new.) The location of the tower at Vint Hill would afford excellent radio coverage in the problem area on either side of U.S. Route 29 near New Baltimore. It would fill in the coverage needed east of Baldwin Ridge and the Pond Mountains and provide in-building coverage to Ritchie Elementary School, Auburn Middle School and the new County High School. Excellent radio coverage would obviate the need for in-building bi-directional amplifier systems at these locations, saving the County several more hundreds of thousands of dollars.

The Vint Hill tower has a clear line-of-sight to View Tree Mountain, where the County has its prime / master site for the public safety radio system. The unobstructed line-of-sight means that an economical microwave link could be installed, eliminating the cost and hassle of locating an intermediate "relay" site for microwave repeaters. Recent advances in technology will afford the County an opportunity to install a broadband microwave link to Vint Hill – far beyond the single DS-1 required for the simulcast radio equipment. SONET OC-3 equipment has, in fact, become so affordable that the additional cost for extra bandwidth is inconsequential. The broadband link would allow the use of the Vint Hill tower site by other County departments and agencies (IT, County Schools, Parks & Recreation) for point-to-point delivery of high-speed data applications.

In this option (Vint Hill tower), Fauquier County will maintain total control of its radio resources and not be subject to failures or problems due to the lack of performance by other parties. The coverage provided by the tower at Vint Hill would truly fix the anomalies reported and verified in the problem area surrounding New Baltimore. First responders like the Sheriff, firefighters and emergency medical personnel would be able to accomplish their mission of protecting citizens and property. (Remember that it was an incident with a house fire where firefighters could not communicate inside the structure that started this study.)

Alternative 7, Option 1 is the most economical choice. Note that the use of Vint Hill will eliminate the need to build a new tower, will eliminate the need for intermediate microwave repeater sites (and towers), will eliminate the requirement for in-building bi-directional amplifier systems at the three local schools, and may provide a very economical option for delivery of high-speed data for the County Schools, Parks & Recreation and other IT applications.

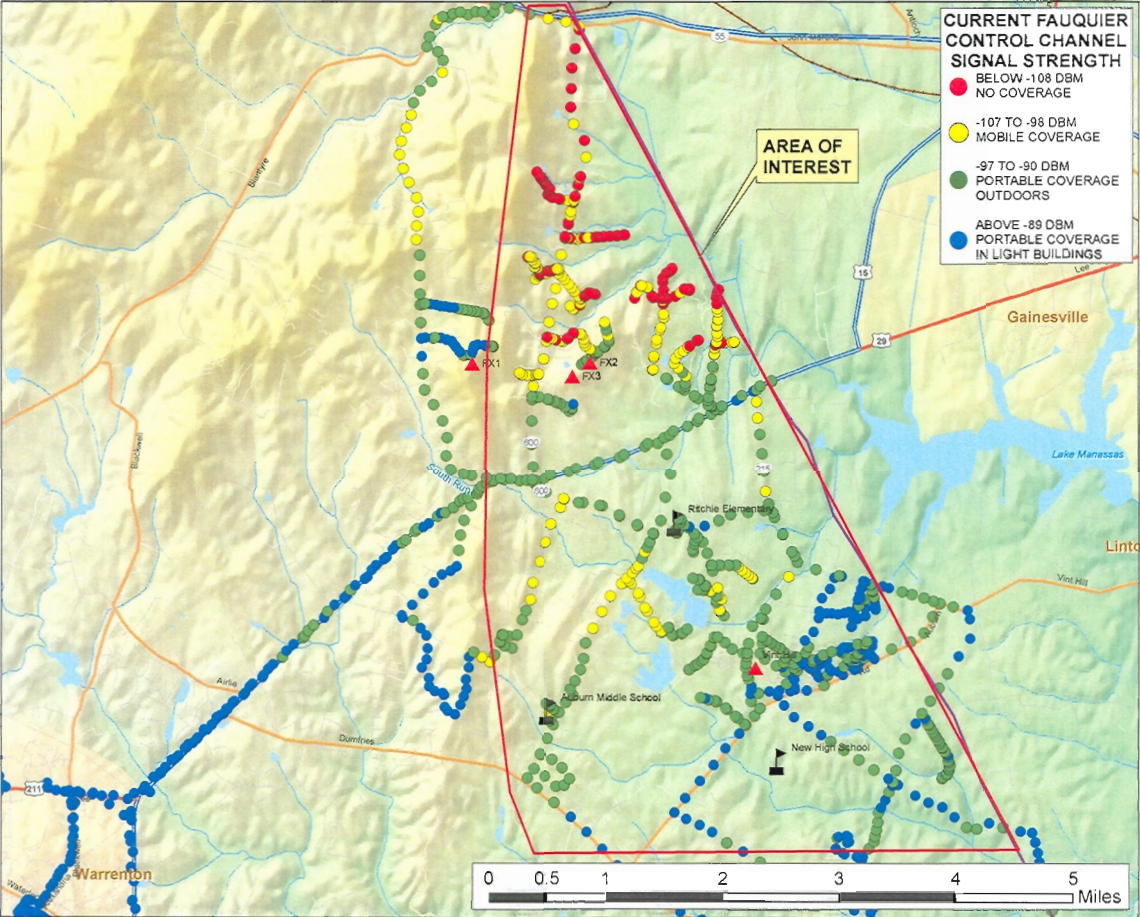
Use of this tower will eliminate the need to build a new tower at a new location in the County.

By constructing a sixth simulcast site, the operation of communications equipment by County first responders will continue to be simple and uniform throughout the County. This makes for a safer working situation for public safety personnel who are frequently placed in highly stressful situations as part of their service to the citizens and community.

It should be noted that the window of opportunity for this option (to build a sixth simulcast site) will close at the end of 2009 due to Motorola's planned phase-out of the ASTRO 4.1 product line.

CTA Communications recommends that Fauquier County adopt the plan to construct a sixth simulcast site, as an expansion of the Public Safety Radio System, at Vint Hill for the purpose of improving coverage in the New Baltimore area.

CTA further recommends that the County immediately take the necessary steps in preparing specifications for the facilities and upgrades required at Vint Hill, and in researching the regulatory requirements for modifying the existing FCC licenses for radio frequencies. CTA can assist County in the preparation of bid documents, in the preparation of FCC applications, in oversight of the construction, installation and testing of new facilities, and in consulting services to assure the employment of best engineering practices for an economical and functional system.



Topographic Features in Problem Area

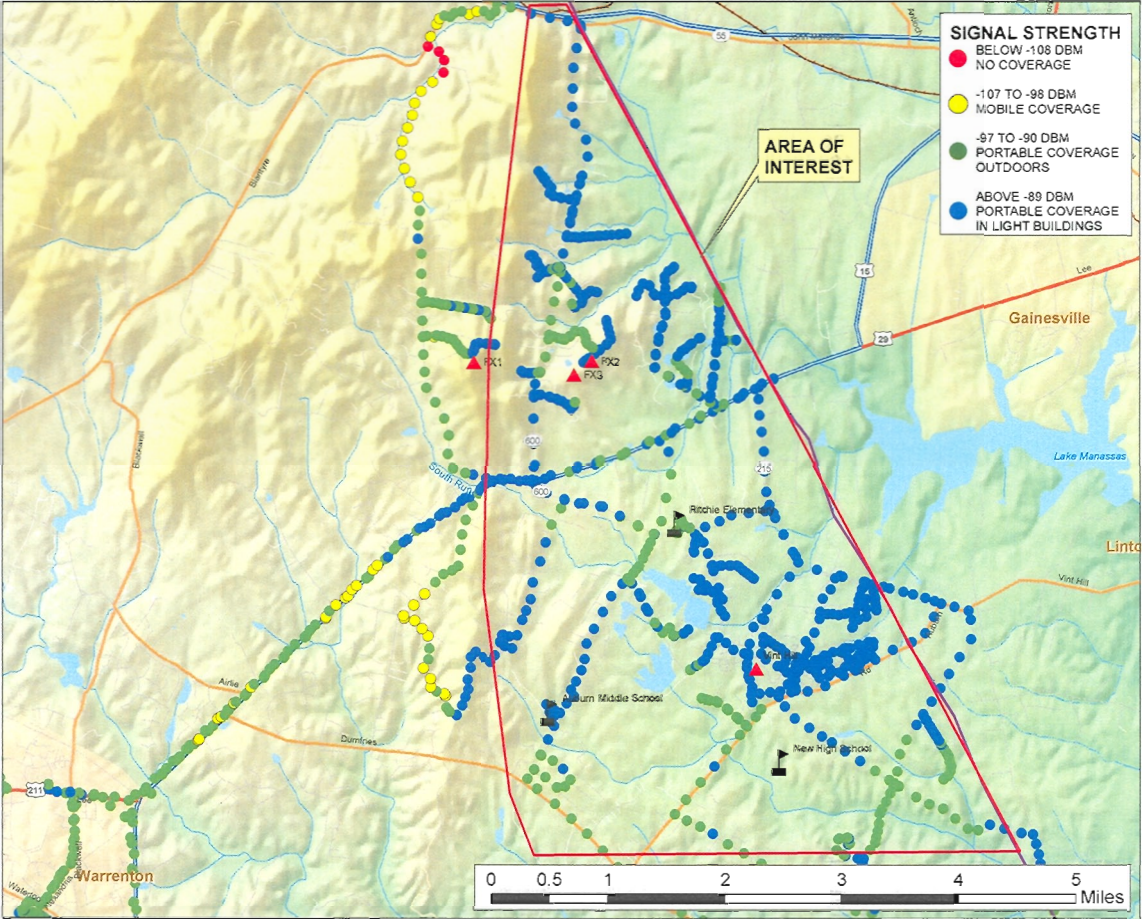
With overlay showing the measured Fauquier control channel level

Client	Fauquier County	Commission No.	201049
Figure Number	1		
Data Sources and Notes:			
Data was collected with 2 signal strength measurement receivers making duplicate independent measurements of the control channel on 868.7125 MHz and one additional channel on 868.5500 MHz as well as 2 channels for each of the surrounding counties. The results from only one of the measurement receivers is shown. Both measurement receivers indicated essentially the same results			
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Drawn:	JRW - 3 MAY 2006		
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Approved:	KAB		
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N
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S



Prince William Co.
Control Channel in
Problem Area

Client Fauquier County Commission No. 201048

Figure Number 2

Data Sources and Notes:

Data was collected with 2 signal strength measurement receivers making duplicate independent measurements of the control channel on 868.7125 MHz and one additional channel on 868.5500 MHz as well as 2 channels for each of the surrounding counties. The results from only one of the measurement receivers is shown. Both measurement receivers indicated essentially the same results

Design: JRW

Drawn: JRW - 3 MAY 2008

Checked:

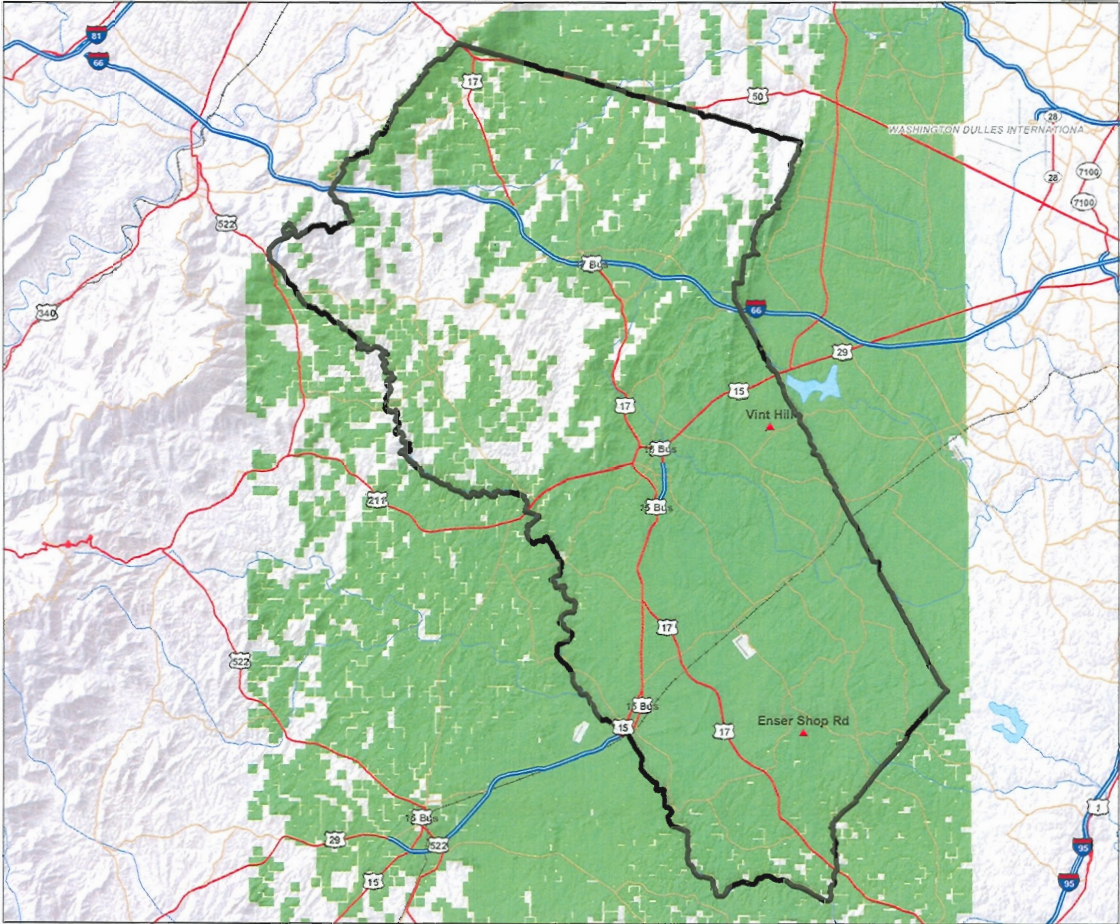
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Fauquier County

Client: Fauquier County

Commission No. 20104B

Site: Vint Hill

Estimate Mobile
Talkin Coverage

Figure 3

*Coverage displayed on this document is the result of predictive technical modeling based upon client provided parameters and USGS topographic data. Actual coverage, as experienced by users in the field, may vary due to unknown and/or unmodeled variables.

Design:	HWY July 26, 2006
Drawn:	YRM - 15 November 2006
Checked:	HWY - 16 November 2006
Approved:	KAD - 17 November 2006

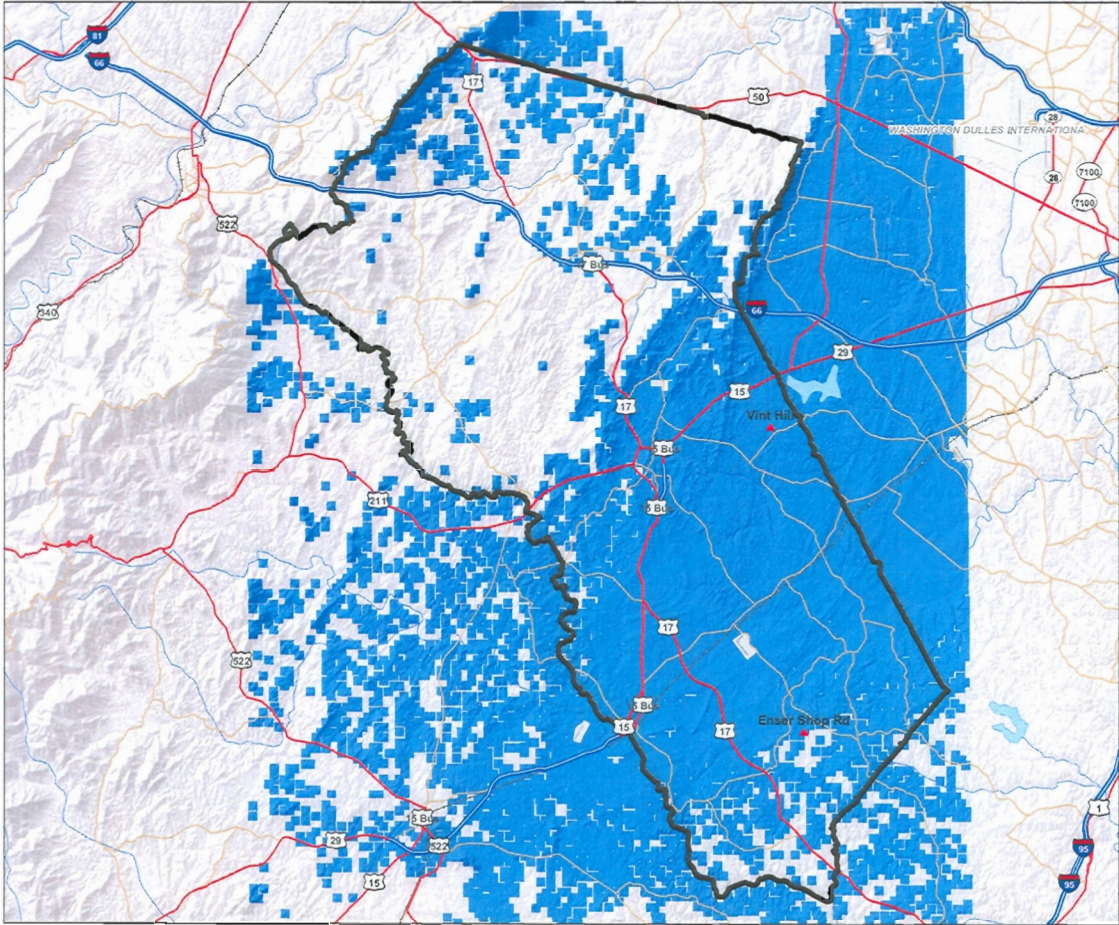
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Fauquier County

Client: Fauquier County

Commission No. 20104B

Site: Vint Hill

Estimate Portable on Hip
Talkin Coverage

Figure 4

*Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters and USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to unknown and/or indeterminate variables.

Design: HWW July 26, 2006

Drawn: TRM - 15 November 2006

Checked: HWW - 16 November 2006

Approved: KAS - 17 November 2006

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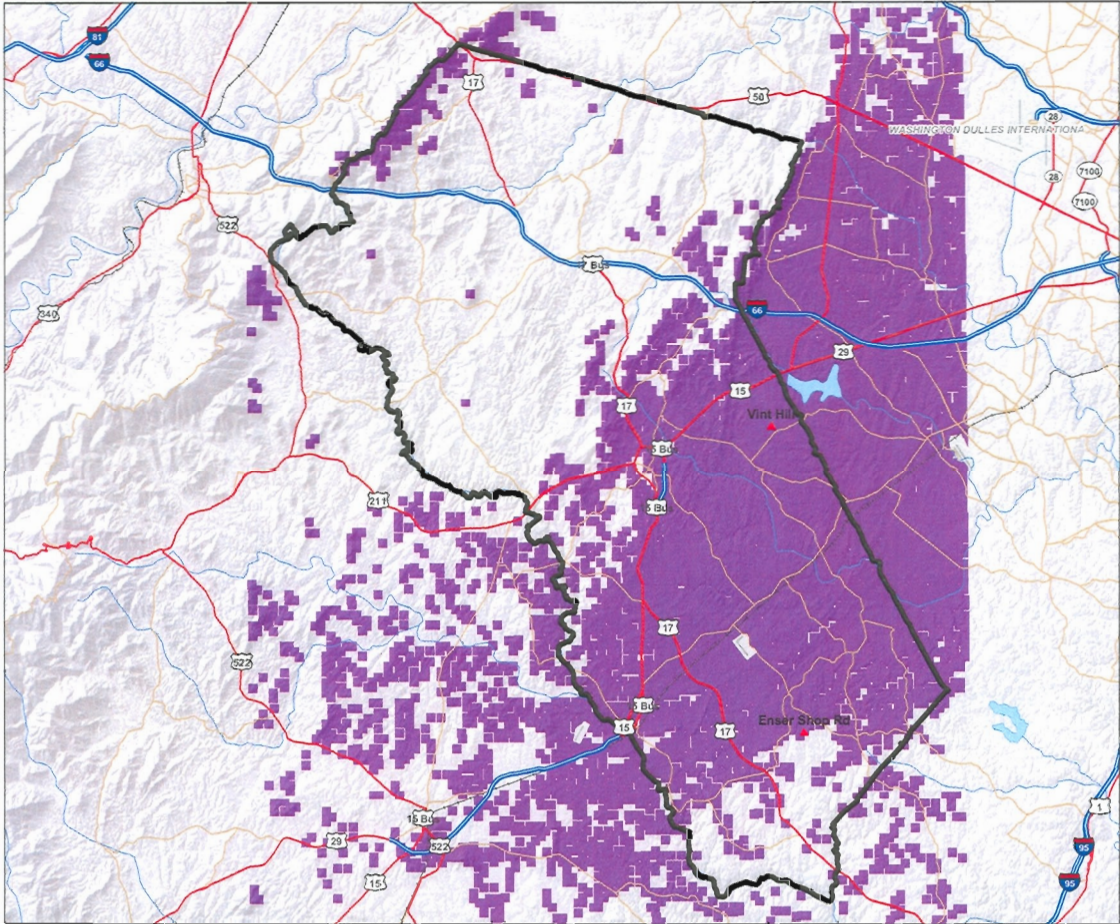
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Fauquier County

Client: Fauquier County

Commission No. 20104B

Site: Vint Hill

Estimate Portable Light Building
Talkin Coverage

Figure 5

Coverage displayed on this document is the result of a preliminary simulation modeling based upon client provided parameters and USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to unknown and/or indeterminate variables.

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Drawn:	TBM - 16 November 2006
Checked:	HWV - 16 November 2006
Approved:	KAD - 17 November 2006

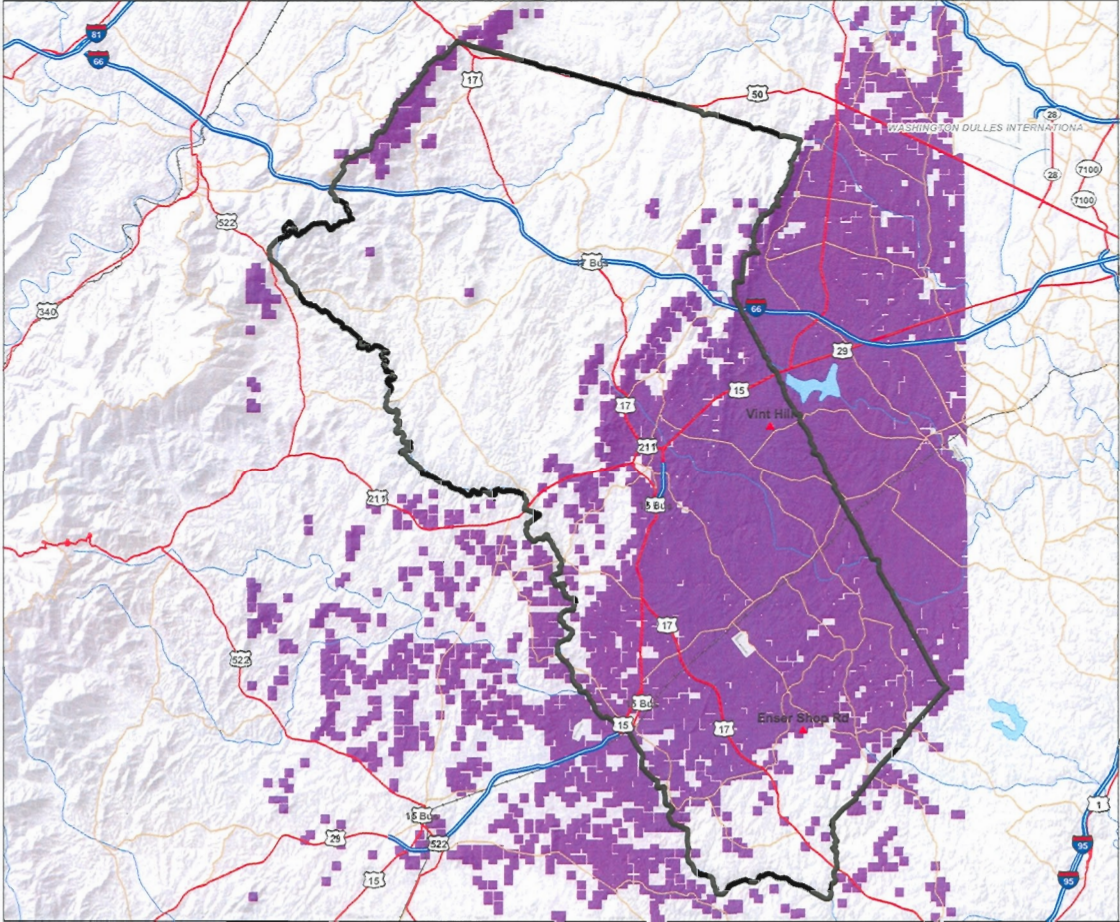
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Fauquier County

Client: Fauquier County

Commission No. 20104B

Site: Vint Hill

Estimate Portable Medium Building
Talkin Coverage

Figure 6

*Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters and USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to unknown activity and/or terrain variables.

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Drawn:	TRM - 15 November 2006
Checked:	MWW - 16 November 2006
Approved:	KAB - 17 November 2006

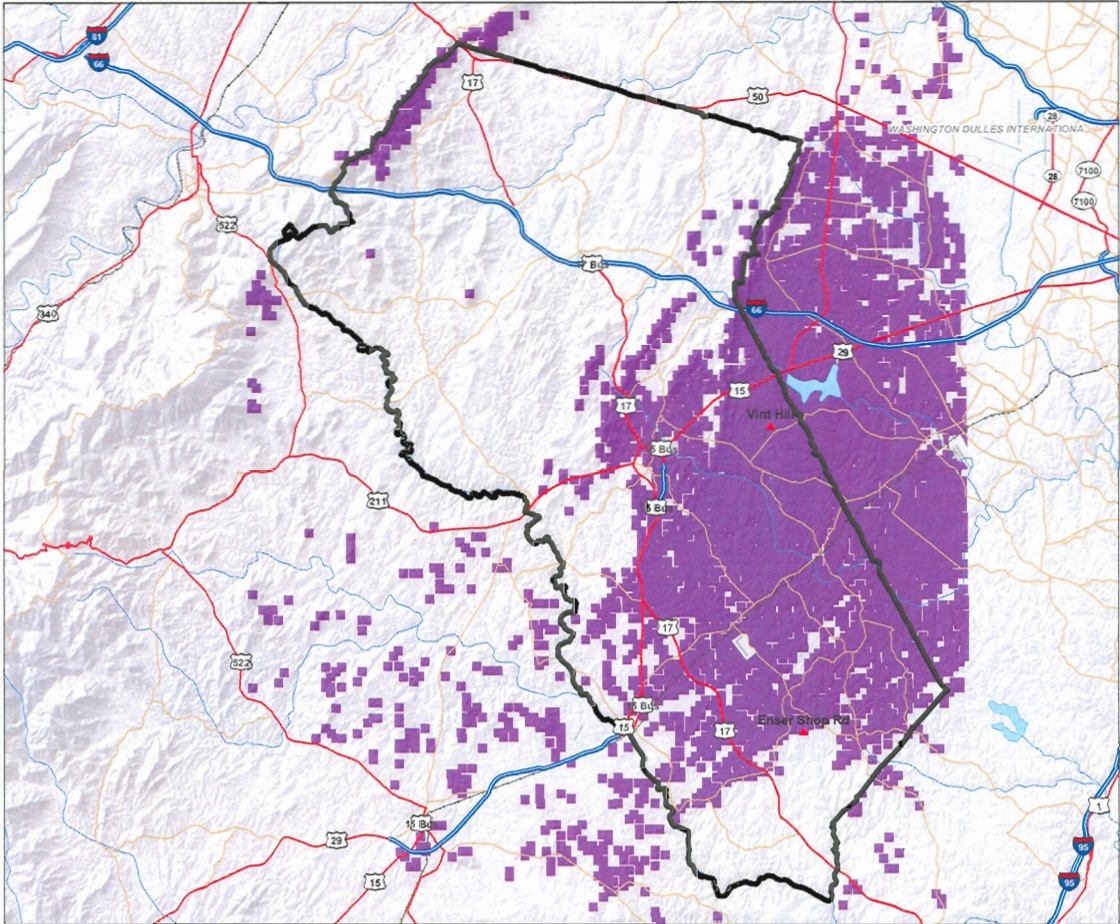
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Fauquier County

Client: Fauquier County

Commission No. 20104B

Site: Vint Hill

Estimate Portable Heavy Building
Talkin Coverage

Figure 7

*Coverage displayed on this document is the result of predictive statistical modeling based upon client provided parameters and USGS geographical data. Actual coverage, as experienced by users in the field, may vary due to unknown and/or indeterminate variables.

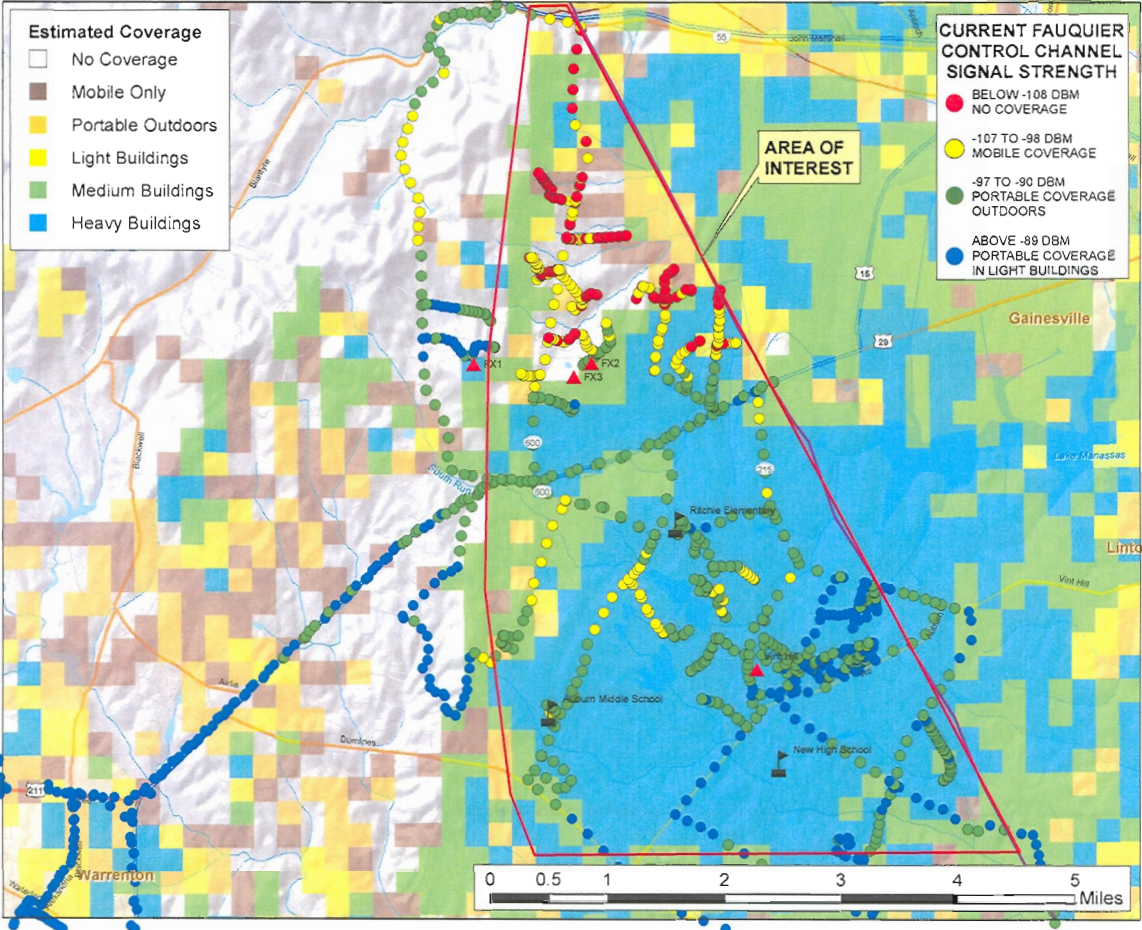
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Drawn:	TRM - 16 November 2005
Checked:	HWV - 16 November 2005
Approved:	NAB - 17 November 2005

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Vint Hill Site Estimated Signal in Problem Area

With overlay showing the measured
Fauquier control channel level

Client: Fauquier County Commission No: 201045

Figure Number: 8

Data Sources and Notes:

Data was collected with 2 signal strength
measurement receivers making duplicate
independent measurements of the radio
channel. The results from only one of the
measurement receivers is shown. Both
measurement receivers indicated essentially
the same results.

Coverage predictions are made utilizing
industry standard adjustments for estimating
the faded sensitivity of receivers expected to
be utilized in the intended application.

Design: JRW

Drawn: JRW - 3 MAY 2006

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Approved: KAB

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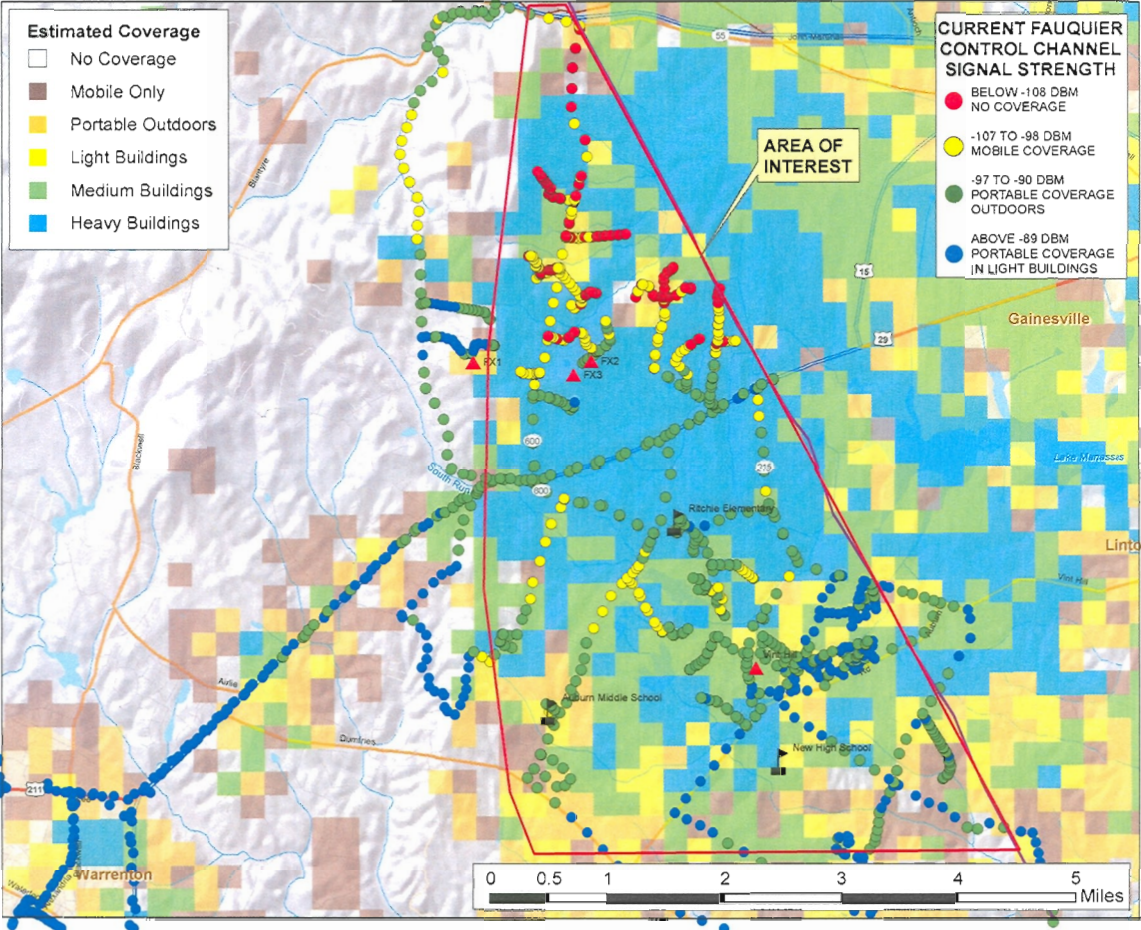
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**Potential FX-2 Site
Estimated Signal in
Problem Area**

With overlay showing the measured
Fauquier control channel level

Client: Fauquier County Commission No.: 201048

Figure Number: 10

Base Sources and Notes:

Data was collected with 2 signal strength measurement receivers making duplicate independent measurements of the radio channel. The results from only one of the measurement receivers is shown. Both measurement receivers indicated essentially the same results.

Coverage predictions are made utilizing industry standard adjustments for estimating the faded sensitivity of receivers expected to be utilized in the intended application.

Design: JRW

Drawn: JRW - 3 MAY 2006

Checked:

Approved: KAB

File Name:

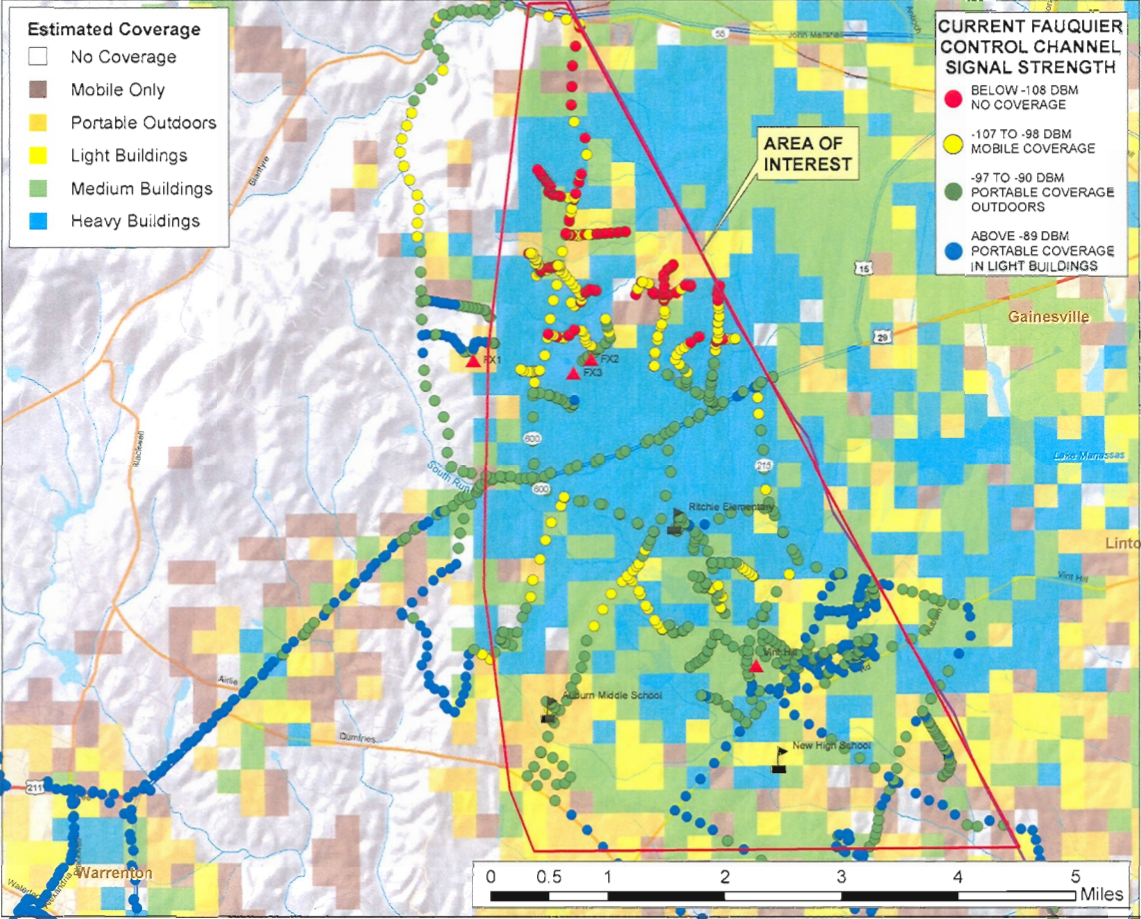
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FX-2 in PA - CG.PDF

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**Potential FX-3 Site
Estimated Signal in
Problem Area**

With overlay showing the measured
Fauquier control channel level

Client: Fauquier County Commission No. 201048
Figure Number: 11

Data Sources and Notes:

Data was collected with 2 signal strength measurement receivers making duplicate independent measurements of the radio channel. The results from only one of the measurement receivers is shown. Both measurement receivers indicated essentially the same results.

Coverage predictions are made utilizing industry standard adjustments for estimating the faded sensitivity of receivers expected to be utilized in the intended application.

Design: JRW
Drawn: JRW - 3 MAY 2006
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Approved: KAB

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